# TURBINE AND ROTOR THEREFOR

## FIELD OF INVENTION

This invention relates to a turbine and rotor therefor with an axis of rotation substansially parallel to a gas / fluid flow. More particularly, this invention relates to an un-enclosed
5   wind / water turbine or a rotor / impellor housed within a duct extracting or converting energy from / to a moving stream of gas or fluid.

## BACKGROUND

On the most part, modern wind turbine rotors are of low solidity and have few long straight blades of " airfoil " section revolving around a central horizontal axis with a
10  large proportion of their blade areas situated within the inner half of their diameters. The very high tip speed ratios involved in obtaining maximum efficiency can greatly add to noisy operating conditions of these turbines. The present inventor has realised that the outer one third of any turbine rotor does most of the useful work in converting the kinetic energy from a moving gas / fluid flow into
15  available torque as torque is a fuction of force x radius, and also that it is more benficial in power production to have an increased gas / fluid flow velocity rather than having an increase in the overall size of the turbine rotor, the present invention seeks to situate the majority of the working surface being presented to the gas / fluid flow in this outer region in an effort to achieve a high mechanical efficiency within a
20  design that remains relatively basic, un-encumbered, free - flowing and is does not rely on high tip speed ratios. The maximum theoretical percentage of energy that can be extracted from a wind flow is % 59.3 ( the BETZ limit ) and this invention has shown University supervised wind tunnel test results supporting of a maximum co-efficient of power above % 52

25              STATEMENT OF THE INVENTION

This invention seeks to provide a high efficiency output from any wind, water, steam, or gas turbines that have a rotation axis generally parallel to fluid / gas flow by using a rotor design that increases through - flow velocity by having a total flow outlet area formed by the gaps or voids between its blades / vanes much greater than the inlet
30  flow area pre - determined by the maximum rotor diameter and also situating the majority of the working suface area in its outer extremities maximising total power output for its size, and comprises of a central hub or shaft rotatable about an axis substansially parallel to gas / fluid flow supporting a plurality of integral blade / vane units equi-distant and radially arranged around the said hub or shaft that each contains within, an
35  integrally formed combination of typically short inner blade or " wing " portions extending substansially outwards from the said hub or shaft, and a substansially frontwardly extending outer " vane " section preferably normal to and joined to the outer, frontward extremity of the said inner portion with the whole vane / blade unit being mounted onto the hub / shaft so as to form a helix or pitch angle between its outer radial extremities and
40  the said hub / shaft axis centre line preferably between 0 - 6 degrees more than the resultant angle corresponding to the resultant sum of the incoming gas / fluid flow vector and the tangental gas / fluid flow " headwind " component due to rotation and the complete revolving rotor assembly encouraging the flow from being generally parallel to its axis to moving outwardly and rearwardly in an increasing " helical "
45  path preferably exitting in most part past the frontwardly projecting outer vane sections that preferably contain within each, an appropiate angle of incedence at any section along their longitudal axis, to the resultant fluid / gas vector flowing past that same specific section irrespective of where that section is located or its specific cross section and most preferably that angle of incedence is between 5 and 15 degrees.

As each blade / vane unit is preferably balanced both in weight distribution and twisting ( moment ) forces due to " lift " from fluid / gas flow , about its own central mounting point centerline normal to the hub or shaft , there is less or no need for an annular stiffening rim at its forwardmost perimeter or midsection connecting it to the other blade / vane unit /s ,

5 which simplifies manufacturability whilst retaining the ability to operate at much higher angular velocities as could otherwise have been been expected without excessive flexing or failure due to large bending or twist stress levels and this design also retains the possibility of the inclusion of blade / vane articulation to a differing " attack " angle for the purpose of speed limiting or start - up situations .

10 In the preferable form of this invention, slightly curved slots have been positioned in the outer rearward ends of the outer portions or vanes extending approximately perpendicular to the " resultant " flow in this region resembling in cross- section a slotted wing or " Fowler flap" greatly increasing the lift forces in this said region , enabling the rearmost end of the blade / vane unit to oppose and balance large moment forces formed by the use of

15 extra ordinarily pronounced forward projecting vane portions and if desired , to completely overcome these forces and twist the vane section to a lesser helix or " attack angle " feathering the vane further into the incoming flow enabling maximum speed limiting due to vane / blade flex at a pre- determined flow velocity .

Preferably , this turbine rotor design is a wind turbine , how ever this does not diminish

20 its ability to provide a useful design alternative to any gas , fluid or steam turbines that may be employed in a variety of different situations where the maximum available space may be limited .

To assist with understanding the invention , reference will now be made to the accompaning drawings which show details of some examples of this invention however it is to be understood that the features illustrated in and described with reference to the drawings are not to be construed as limiting the scope of the invention .

5    In the the drawings :
Figure 1 shows a top view of the preferred embodiment .

Figure 2 shows the frontal view of the preferred embodiment , excepting the number of blades and    # 2 being the direction of rotation in this instance.

Figure 3a , 3b and Figure 4 shows various section cutaway views of the preferred integral
10   blade / vane unit depicting the relationship between the resultant gas / fluid flows 11 # and the the angles of incedence $\alpha$, to the blade / vane cross section at that same position with Figure 3 b also showing the preferred cross section in the vicintity of slot # 5

Figure 5 is an isometric view of the preferred embodiment.

Figure 6 " A " depicts a simplified multistage turbine embodiment having a second stage
15   with a differing angle of attack on its blades and direction of rotation than the first stage to maximise resultant lift forces directed into torque at the hub and may have pre - rotor vanes.

Figure 6 " B " shows a method of achieving blade angle of attack adjustment with a mounting shaft protruding from the lower central mounting line # 8 of the blade / vane units which can be articulated by mechanical means built into the hub .

20   Figure 6 " C " shows an embodiment without slots that may be more easily manufacturable using the pressed metal or vacuum formed methods that also has an annular rim attached to the forwardmost perimeter of the blade / vane units to increase rigidity.

Figure 6 " D " depicts a simplified 2 stage fan that may be enclosed in a duct to suit air craft / hovercraft that has a second rotor with a differing rotation direction and blade pitch angle so as
25   to enable the flow produced by rotation to exit at a typically lesser angle without sacrificing pitch length and so actual rearward thrust ( that consists of V1 axial plus V 2 axial components )

Figure 7 shows a face - on view of a blade / vane unit of the preferred embodiment with reference to the design formulae scaled for any given turbine diameter , with : -
    " D "    =    maximum rotor diameter
    CL max = the maximum lift co-efficient for a blade or wing unit area
    Y    = the total area of blade / vane rearwards of the central mounting point line # 8
    X    =    the total area of blade / vane forward of the central mounting point line # 8
    A in = area of flow intake    ( = rotor radius squared x phi . )
    A circ = area of flow exitting outwards at perimeter of vanes .
    A thru = area of flow exitting at rear of rotor
    $\Theta$    = pitch or attack angle of blade / vane units to the hub / shaft axis
    $\omega$    = the angle between the vanes leading inner edge # 7 to the hub / shaft axis #6.
    $\phi$    = the angle between the blade section leading edge to the central line # 8
    # 1    =    outer vane section
    # 3    =    inner blade section
    # 6 =    hub / shaft axis centerline
    # 8 =    the central line passing through the centroid of areas #10 perpendicular to the hub or shaft axis .
    # 9    =    the area of junction between the blade/ vane and the central hub or shaft
    # 10 =    the centroid of area about which the total sum areas of the blade and vane sections are considered to be centered upon .
    # 11 = the " Resultant" flow vector comprising the sum of the axial flow velocity the radial flow velocity and the tangential flow velocity due to rotation .
    # 12 = the incoming flow direction
    # 14 =    the angle between the vane / blade outer trailing edge and the hub shaft axis .

Figure 8  is the conclusional page to a University supervised wind tunnel test on a  765 mm Dia. rotor.

Referring to figure 1,
A plurality of  eqi-spaced  integrally formed  " crooked "  blade / vane units  that consist of most
preferably  an inner  airfoil  section blade   # 3   that extends  substansially  outwards  radially
5  from a central  hub or shaft  # 4  at a slight rearward  angle , each  inner blade  having  a  leading
edge  also   rearwardly sloping  between 5 and 60 degrees  from  normal and   a  substansially
frontwardly protruding vane  section # 1  integrally formed with  and  joined to  its  outer  frontward
edge  and the whole  blade / vane unit  generally  twisted  in a  helix  or  pitch angle ϴ  about
the   hub /shaft central axis   # 6  that is  preferably  parallel  to  the  gas / fluid  flow direction  # 12
10  so as to maximise the  lift or deflection  forces obtained  from  the  resultant flow  and converted
into  available  torque .
The vane section  # 1 is  preferable of an air foil  cross section that diminishes  in  chord  length
in  proportion to its  distance away from  the  inner blade section # 3   to  form  a  curved  outer
point  leading  into the oncoming flow.


15    Referring to Figure 7
The vanes  # 1   preferably  contain slot /s  # 5  within  their  outer rear section  that are  set
approximately  normal to the  resultant flow  # 11  past  that  same  said  section and
may  be curved , each slot being quite  narrow with a  smoothly rounded exit edges so
as  to direct   a portion of the gas / fluid flow through  to the rearward face of the vane  / blade
20  unit  providing an  increase of  " lift ' forces in this region  ( Figure 3 b )  and  most preferably
forming  a secondary  " curved " or airfoil cross section  in this area   and  enabling  a  large
increase in  the  co-efficient of  lift   in  this  rearmost vane area  being useful  in  balancing  a
pronounced  front section of vane   area  having  a  lesser co-efficient of lift  per unit area
which can   allow for equilibrium to be maintained  due to  moment or twisting forces about the
25  central  line  # 8  passing  through the total vane  / blade area centroid  # 10  normal to the  hub
axis # 6 .

Also , preferably ,  the total mass foward of the central line # 8  ( area x -x )  is equal to  the
total mass  rear of  the central line # 8  ( area y - y )  enabling  a fully balanced blade design to
be achieved  as the central line # 8  passes through the centriod of area  # 10    perpendicular
30   to  the   hub axis  centerline # 6 .

The central hub  # 4 could be  constructed in a variety of  shapes  and  sizes  but  preferably
has  a diameter  of  between 0.2 and 0.4  of the total rotor diameter ,  increasing in
diameter  in a smoothly  curved  cone shape  towards  its  rear helping  to direct  flow
outwards and rearwards  without  imparting  excessive turbulence and   providing  a  possible
35   housing  for  blade articulation  mechanisms ,  a generating unit  or connection to  a  suitable
output  shaft    and / or  support bearings .

It can be seen  from Figure 1   that the general  shape of the complete rotor  is  designed  to
to impart  a fluid or gas flow pattern  that  has  a substansial  outward  direction as it moves
further into and  completely  through  the  rotor .

40    As the total exitting  flow area  " A thru " plus " A Circ "  is much larger than the  total inlet flow area
" A In "   with Volume - in  being  equal  to  Volume - out  and  Volume equal to velocity x  area
then it follows   that  from Bernuilies principle that there must be  an  increase in  velocity  inside /
frontward of  the  rotor or a  pressure drop  outside / rearward of the rotor all of which
improving  turbine rotor  performance  over  prior art .

45    All the  leading edges are  preferably  suitably rounded  to  minimise turbulence  and  a  good
surface finish  is applied  to all sections  with the  inner blade section  being of  sufficient
strength  to adequately  transform  or direct  the  sum  of the  deflection and   " lift " forces
from the blades , vanes and  slots   due to fluid / gas flow   into torque at the  hub or  shaft
and  to be able to withstand centrifugal and  bending forces due to the total mass revolving
at the maximum rated  speed  in extreme conditions .